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Study of the relation between types of the quality costs and its impact on productivity and costs: a verification in manufacturing industries

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Quality management aims to create a high-quality, high-performance product or service that meets and exceeds the customers' expectations. This research seeks to highlight the concept of quality control (QC) and quality costs as essential elements which are the rudiments controlling the survival of organisations in the marketplace. This requires spending on two types of quality costs, prevention costs (PCs) and appraisal costs. These costs aim at the reduction of two types of quality costs, internal failure costs (IFCs) and external failure costs (EFCs). It also takes account of the investment in QC team IFCs and EFCs. This research is tailored towards clarifying the nature and the relationship between types of quality costs and total quality costs. Moreover, it seeks to measure the impact of quality improvement on productivity and costs, hence creating a practical opportunity for improvements for organisations. The study collected data from a textile company's records in Iraq. The field cohabiting method was followed by the researcher to highlight the main results of this study. Technological obsolescence led to an increase in the proportion of products requiring re-work or scrapping, thereby increasing costs and decreasing the levels of quality and productivity. The results also indicate that there was a PCs weakness in maintenance and protection programmes affecting quality and productivity.

Keywords: total quality management; total quality costs; productivity

1. Introduction

Quality has become a very broad concept. The concept no longer just refers to the high quality of products; it also encompasses quality in terms of service delivery, timeliness, after-sale services and the production process itself, and this requires a focus on continuous improvement (Tolentino, 2004; Acharya & Ray, 2000). Deming stated that 'the consumer is the most important part in the production line, and it must be the goal of quality to meet the consumers' needs of present and future' (Taylor III & Russell, 2000). For years, quality and productivity have been viewed as two important indexes of company performance, especially in manufacturing industries. However, they are always examined separately. The main reason that quality and productivity are not examined simultaneously is that the objectives of quality management (QM) and productivity management are traditionally viewed as contradictory (Deming, 1986; Belcher, 1987). Recent research indicates that quality and productivity should have a positive relationship. However, this theory is primarily based on logical reasoning and not empirically tested models. Therefore, this study will develop an empirical relationship between both variables.

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2. Literature review

There needs to be clarification of the meaning of total quality management (TQM) and quality control (QC). In this regard, the British Specification (BSISO) defines a quality as the characteristics and features of the product or service that satisfy the explicit or implied needs of the client. This specification examines the impact of the implementation process on ISO 9000 performance (Wilkinson & Cooper, 1997; Arauz & Suzuki, 2004). While the American Society of Quality defines quality as: the set of characteristics and the features of the goods and services that depend on its ability to meet the specific needs of consumers (Heizer & Render, 2001). On this basis, it is believed (Al-Dujaili, 2002) that quality is the extent of the congruence between the characteristics of the product and the needs and desires of consumers. Taking this into consideration, it is possible to build an appropriate strategy for quality, and then formalise design. Then, the conformity of the product to the design is checked. Moreover, guidance is provided to investigate the consumers' use of and reaction to the product.

On this premise, the overall approach to QM requires the participation of all the creative minds in the work, where employee involvement is defined as 'a range of processes designed to engage the support, understanding and optimum contribution of all employees in an organisation and their commitment to its objectives', while employee participation is defined as 'a process of employee involvement designed to provide employees with the opportunity to influence and where appropriate, take part in decision-making on matters which affect them'. Therefore, participation is considered one of the most important pillars for the success of this model, but is often misunderstood. However, it helps in two ways (LTSN Hospitality, Leisure, Sport and Tourism, 2001):

(1) It increases the possibility of designing the best plan,
(2) It improves the efficiency of decision-making through the participation of creative minds. Here, we must point out that these are the minds that are close to the work research problems, and not all the employees in the organisation.

However, to achieve this is Choo, Linderman, and Schroeder (2004) stated that learning behaviours and knowledge influence performance directly, as well as affecting the mediation of relationships between mechanisms and performance. Consequently, in practice, the focus has been mainly on organisational performance and the reduction of defects in the manufacturing process. Performance measures can be used to force an organisation to focus on the right issues and make decisions effectively (Parker, 2000; Dale, Y-Wu, Zairi, Williams, & van der Wiele, 2001). Accordingly, performance quality has become meaningful as an expression of productivity. Furthermore, quality is a criterion for the organisation to grow and compete at a regional level (Taylor III & Russell, 1995). Consequently, in an era of tight budgets and increased outsourcing, getting a good measure of an organisation's productivity is a persistent management concern; organisations must craft productivity measures appropriate to their processes and information needs that meet specific performance targets between quality and productivity. In other words, it does not promote any specific productivity measure as a general solution without quality (Card, 2006). This means that improvement in any area leads to an improvement of other elements to generate sustainable competitive advantage (Ross, 1995; Reed, Lemak, & Mero, 2000). However, many would argue that outputs may be measured in terms of delivered product or functionality, while resources may be measured in terms of effort or monetary cost. Therefore, today's organisations translate this new concept into observable and measurable elements so as to form an index of measurement of the

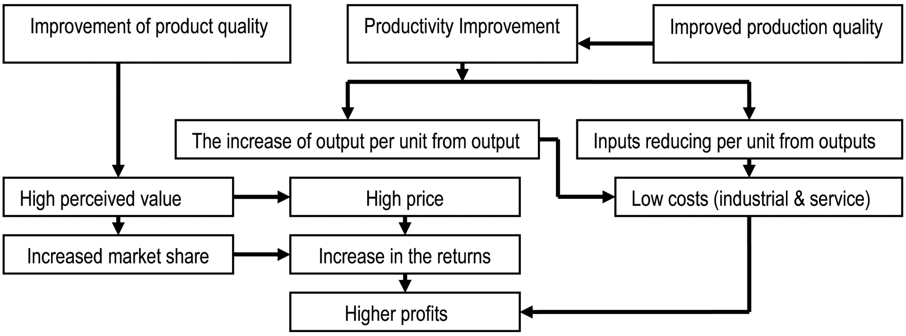

Figure 1. Improvement of quality and productivity leading to increased profits.
Source: Evans (1997).

concepts of quality and productivity (Bergman & Klefsjo, 1994;Ali & Zakria Abas, 2001). Accordingly, it can be said that profitability may be very sensitive to any changes that occur in productivity and quality. On the other hand, the improvement of production quality leads to a reduction in losses due to waste and the reduction of re-work, leading to lower costs, thus, increasing profits substantially as illustrated in Figure 1.

Figure 1 shows quality as a central part of measuring productivity. Productivity measurement by dividing the output by the input is incomplete if it does not take into account quality elements, such as rejected or poor-quality products. Because productivity improvement does not just mean the efficient production of any product or service but of products and services that are needed, demanded and bought by discerning customers and society at large. Customer orientation is now a prime consideration and superior quality is a major indicator of good productivity performance. Productivity is becoming synonymous with quality. At the same time, quality is also becoming a much broader concept. This refers not only just to high quality embodied in the attributes of products but also encompasses quality in terms of service delivery, timeliness, after-sale services and the production process itself (Tolentino, 2004). In this study, the measurement of Taylor III and Russell (2000) will be used to analyse the relationship between quality and productivity. This depends on measuring product yield and productivity in a way that shows the final product or finished product as a measure of output, which is often used as an indicator of productivity. Equation (1) can be used to calculate internal production processes during the first stage in the process:

$$Y = (I)(G\%) + (I)(1 - G\%)(R\%), \tag{1}$$

where I is the planned number of used units in the production process, $G\%$ the percentage of good units and R% the percentage of defective or rejected units. An increase in the value of the final product points to an increase in productivity.

Meanwhile, the second relationship represents product yield cost, as explained in Equation (2):

$$\text{Product cost} = \frac{(\text{Kd})(I) + (\text{Kr})(R)}{Y}, \tag{2}$$

where Kd is the forthright industrial costs, *I* the inputs, Kr the costs of re-working a unit, *R* the number of returned units and *Y* the yield.

A decline in this ratio indicates a positive relationship between productivity increase and reducing costs. When the two relationships are taken together in one case study they can explain the relationship between quality improvement and productivity, because both have used quality elements in the measurement of productivity via the expression of elements such as good products, poor-quality products and the costs of manufacture. Methods to improve quality (traditional or modified) and their implications on the rates of poor-quality and good-quality products can determine productivity's relationship to quality, whether the improvement of quality increases or decreases productivity (van der Wiele, Willimas, & Dale, 2000). However, if there is high employee turnover and an extensive learning curve (knowledge), creating a management environment to increase employee job duration based on new hiring strategies, reward and recognition programmes and other labour retention tactics can increase productivity while simultaneously increasing quality. The cost of managing longer employee job life cycles is significantly lower than many other options (Borton, 2004).

The discussion above shows that if organisations do not have the information to understand the relationship between quality improvement, productivity and costs, they will not have what they need to meet organisational and workforce goals (Bergman & Klefsjo, 1994). There are two different views about the relationship between quality, productivity and costs. Some see quality improvement leading to reduced productivity and increased costs, as a result of reject detection and isolation from yield. This is a reference to the traditional trade-off between quality, productivity and costs, termed the American School view of quality. Figure 2 shows the traditional relationship between quality, productivity and cost.

Meanwhile, the Japanese view of this concept takes on several different perspectives. Culture, management style, lifetime employment and QC circles are among the factors that have been proposed as causes for Japanese success. These factors should lead the workforce to error-free operation or to improving on the product quality seen in American industries through the development of control processes during production. In addition, knowledge and information technology are important factors (Ebrahimpour, 1985). Quality improvement can lead to increased productivity and lower costs because of the elimination of damage during the operations. Figure 3 shows the relationship between quality, productivity and costs in accordance with the modern definition.

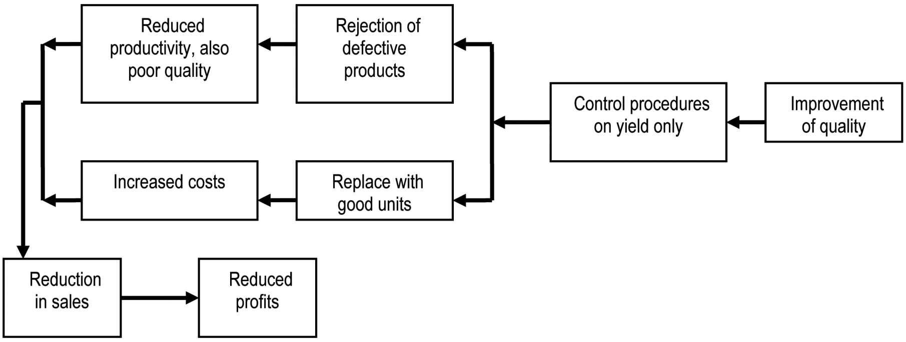

Figure 2. The traditional relationship between quality, productivity and costs.
Source: Deming (1986).

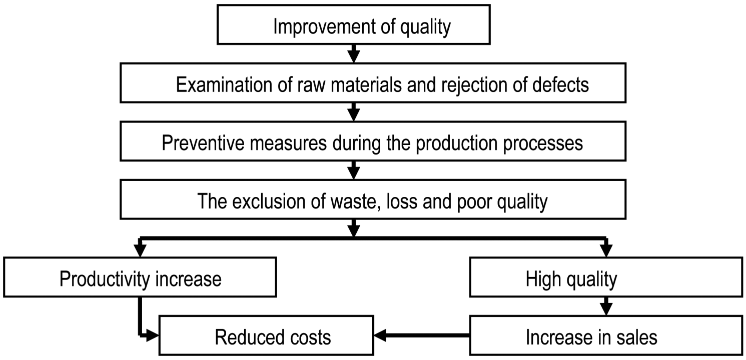

Figure 3. Modern view of the relationship between quality, productivity and costs.
Source: The design is by the author.

The relationship between quality, productivity and costs can depend on the available resources (facilities, skills and tools) and the method by which this potential is used (Adam, Everett, & Ebert, 1986). Traditional definitions concentrate on technological potential and special techniques, while the modern definition of Deming emphasises 14 points to improve quality and productivity, as well as their relationship with productivity. Juran's trilogy, an approach to cross-functional management that is composed of three managerial processes (quality planning, QC and quality improvement) in addition to human aspects (senior management and employees), seeks to influence the relationship between quality, productivity and costs through the composition of quality-control teams and the participation of workers in the detection of problems and their resolution. According to this rule, the workers will know and be able to solve their own problems (Schroeder, 1989). Adam et al. (1986) called the scale to measure the relationship between quality, productivity and costs the quality–productivity ratio. This indicator is calculated as follows (Adam et al., 1986):

$$\text{QPR} = \frac{\text{Good} - \text{quality units}}{(\text{Input})(\text{Processing cost}) + (\text{Defective units})(\text{Rework cost})} \times 100, \qquad (3)$$

where the numerator represents productivity quantities and the denominator represents productivity costs, taking into account the level of the achieved quality, the quality to productivity ratio (QPR) will be high where operational costs or the costs of re-work (or both) are reduced. It will also increase when the production of good-quality units is high compared with the total units involved in the production process.

3 Research methodology

This study used a mixed methods approach to conduct the research. First, there is a comprehensive literature review. The literature review investigates and discusses theories and concepts from books, journals, publications and Internet sources. The outcome of the literature review produced an initial data model to be used in the study of the relationship between the variables. The second (practical) part consists of the practical application to a company of the study domain. Therefore, the study facilitates the examination of different levels of development in using TQM techniques in terms of quality and productivity, thereby leading to the prediction of product costs, finance, time, professionalism, perception and

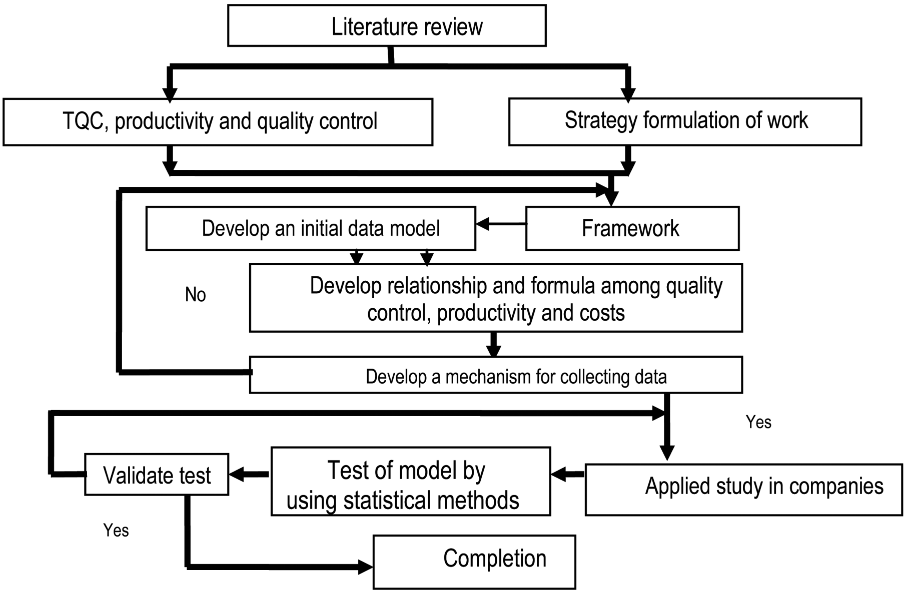

Figure 4. Research methodology flowcharts.

reliability. This should assist decision makers in their strategy and policy setting. The research stages are as follows: (1) Develop an initial data model based on literature review. (2) Assess the relationship and construct a formula between TQM, productivity and QC. (3) Develop a mechanism for collecting data to support the formula/case study. Test the model using statistical methods. (4) Use the data collected from the case study to validate the models and formula. Figure 4 illustrates the stages of this research. Therefore, the research will stem from this question: Is there any statistically significant relationship between methods of improving quality, productivity and costs in factory 1? This was done in accordance with Adam and Hershauer (TaylorIII & Russell, 2000).

4 Results and discussion

Organisations can lose income if they fail to capitalise on significant opportunities to reduce their quality costs. This study used measurements and statistical programs to analyse TQM costs in the manufacturing environment. It also presented the cause and effect diagram for the difficulty in implementing a quality improvement programme in one of the companies of the textile industry in Iraq.

4.1 *Limitation of quality costs, classification and calculation*

The quality costs are categorised into visible and invisible costs (Dahlgaard, Kristensen, & Kanji, 1992). Accordingly, quality costs for 2003 to 2007 in this firm are categorised into visible costs as per Rodchua (2006), Detoro (1987) and Dahlgaard et al. (1992).

4.1.1 *Prevention costs (PCs)*

These are the costs associated with quality planning, designing, implementing and managing the quality system, auditing the system, supplier surveys and process improvements. They include the following classifications: (1) Quality planning costs: include the salary of the manager of quality at the factory, who is responsible for quality planning. (2) Product design costs: the workers' incentives in the quality department, including the engineers, physicists and biochemical technicians responsible for quality design. These funds are spent for the purpose of achieving a good design that is free from defects, and to limit the quality-control process required in the factory. (3) Training costs: staffing expenses in the quality department; a training group in the department of quality control domestically and internationally. Employees should learn the fundamental benefits of quality and the different methods of controlling it. The training programme can be delivered by external professionals in the field or by senior figures within the organisation. (4) Process costs: these are spent on operations and activities with the aim of making production conform to the specified quality specifications. They also include study and research and development costs incurred in order to develop quality. However, we did not obtain the cost of the product and process design. The costs of the quality information system are not given in the factory's recorded production costs. Therefore, these have been excluded.

4.1.2 *Appraisal costs (ACs)*

These are associated with measuring, evaluating or auditing products and raw materials to ensure conformance with quality standards and performance requirements in the factory. They are classified as follows: (1) Quality testing and selection costs: devices and equipment that are used in quality inspection and testing before the product manufacturing process and at the operational stage of manufacturing. (2) Quality equipment maintenance costs: money spent on repairing and testing quality-testing equipment. Also, the cost of the tools and equipment used in the maintenance of the factory. (3) Audit quality costs: the wages of workers who collect the necessary information to measure quality levels and the verification of compliance with specifications. (4) Testing materials costs: the cost of raw materials used in the selection and testing of quality, as well as other associated costs (e.g. papers and stationery) incurred in the recording of data for measurement and selection.

4.1.3 *Internal failure costs (IFCs)*

These are associated with processes, equipment, products and product materials that are defective or fail to meet quality standards or requirements. They are classified as follows: (1) Scrap: defective product, material or stationery that cannot be repaired, used or sold. (2) Re-work or rectification: the correction of defective material or errors to meet the requirements. (3) Failure analysis: the activity required to establish the causes of internal product or service failure. (4) Re-inspection costs: the re-examination of work or products that have been rectified. Also, the costs incurred when a product is usable but does not meet specifications so is downgraded and sold as 'second quality' at a lower price. (5) Process failure costs: the costs resulting from the use of machinery over the long term. These costs were not obtained because they were not known.

4.1.4 *External failure costs (EFCs)*

These are generated by defective products, services and processes during customer use. They include warranties, complaints, replacements or recalls, repairs, poor packaging, handling and customer returns. They are classified as follows: (1) Warranty claims: failed products that are replaced or services re-performed under some form of guarantee. (2) Complaints: all work and costs associated with handling and servicing of customer

Table 1. Quality expenditure at factory 1 (2003–2007).

	Expenditure (thousands of dinars)				
	Year				
Types of quality cost	2003	2004	2005	2006	2007
PCs	6739	38,322	36,724	69,027	66,818
ACs	126,360	135,437	140,201	136,883	271,725
IFCs	178,628	183,933	400,544	308,597	287,716
EFCs	206,098	774,804	183,416	570,855	885,056
Total	517,825	1,132,496	760,885	1,085,362	1,511,315

Source: The records of factory 1.

complaints. (3) Liability: the result of product or service liability litigation and other claims, which may include a change of contract. (4) Sales loss costs: the cost of sales that were planned during the year but customers did not purchase because of their lack of confidence in the company/product. This rate is calculated for a specific year as: lost sales = planned sales – actual sales at year end.

4.2 *Actual costs at factory 1*

Table 1 and Figure 5 show the amount of money spent by factory 1 on the various types of quality measures and their distribution between 2003 and 2007.

Meanwhile, Table 2 shows that: (1) The cost of the quality initiatives at factory 1 ranged between 517,825 thousand dinars (minimum, 2003) and 1,511,315 thousand dinars (maximum, 2007). (2) Compared to 2003, quality costs increased by 47% in 2005 and 192% in 2007. Compared with the previous year, the level of quality expenditure rose in 2004, decreased in 2005, rose again in 2006 and declined again in 2007.

4.3 *Changes in types of quality costs in factory 1 (2003–2007)*

Table 3 shows the relative levels of expenditure by quality cost types in factory 1. (1) Allocation ranged from 1% (PCs in 2003, minimum) to 69% (EFCs in 2004, maximum).

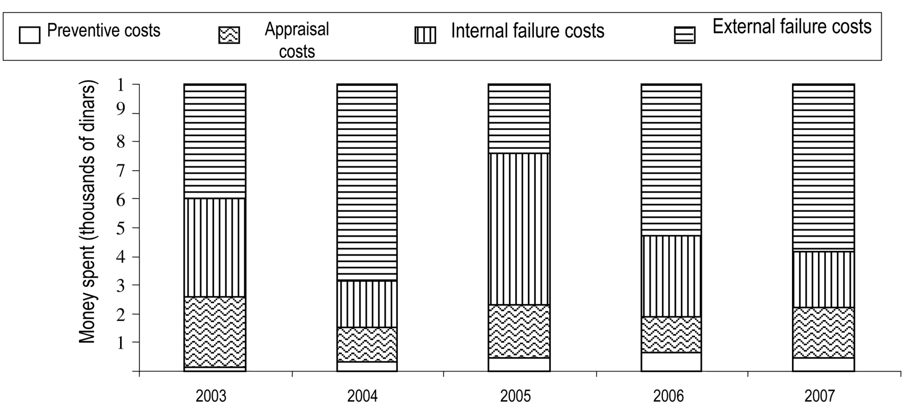

Figure 5. Pareto scheme for the distribution of costs in accordance with quality types in textile factory 1 (2003–2007). Source: Table 1.

Table 2. Rates of change in quality costs at factory 1 (2003–2007).

		Rate of change (%)	
Year	Quality costs (thousands of dinars)	Comparison with basic*	Comparison with previous year**
2003	517,825	Basic	Basic
2004	1,132,496	119	119
2005	760,885	47	***(33)
2006	1,085,362	110	43
2007	1,511,315	192	39

Source: Table 1.

* Rate of change incompany with basic year $= \frac{\text{Costs in the current year}}{\text{Costs for the basic year}} \times 100\%$

* Rate of change in company with previous year $= \frac{\text{Costs in the current year}}{\text{Costs for the previous year}} \times 100\%$

***The rate of a negative change. Source: Chase, Nicholas, & Mark, 1995, p. 131).

Table 3. The relative importance of the different types of quality costs in factory 1 (2003–2007).

	Relative importance (%)				
	Year				
Types of quality cost	2003	2004	2005	2006	2007
PCs	1	3	5	6	4
ACs	24	12	18	13	18
IFCs	35	16	53	28	19
EFCs	40	69	24	53	59
Total	100	100	100	100	100

Source: Table 3.

(2) EFCs represented the most important measure, with rates ranging between 24% (2005, minimum) and 69% (2004, maximum). (3) PCs represented the least important measure, with rates ranging between 1% (2003, minimum) and 6% (2006, maximum). (4) The maximum proportion of ACs was 24% (2003) and the minimum was 12% (2004). (5) The rise in PCs was very small: it rose from 1% in 2003 to 6% in 2006 and then decreased to 4% in 2007.

According to the percentages in Table 3 above, Feigenbaum limited the relative importance of quality cost types that can be calculated as follows: PCs 5–10%, ACs 20–25% and costs of internal and external failure 65–70%. While Juran and Grgna suggested it is calculated as follows: PCs 0.5–5%, ACs 10–50%, IFCs 25–40% and EFCs 20–40% (Chase et al., 1995, p. 131).

4.4 *Relationship between quality costs, production costs, sales value and quantity of production at factory 1 (2003–2007)*

Table 4 shows the quality index relative to the cost of production; it ranged from 17.78% (minimum, 2006) to 44.36% (maximum, 2004). Furthermore, when comparing the quality index with the base year costs of production (2003), the index only rose in 2004 and declined thereafter. When the quality index is compared with the previous

Table 4. TQCs in factory 1 relative to the cost of production, sales value and quantity of production.

Year	TQCs (thousands of dinars)	Production costs (thousands of dinars)	Sales value (thousands of dinars)	Actual production (thousands of metres)	Index of quality costs to production costs (%)	Index of quality costs to sales value (%)	Index of quality costs to production quantities (%)
2003	517,825	2,095,508	2,777,879	9021	24.71	18.64	5740.22
2004	1,132,496	2,552,692	3,086,628	9907	44.36	36.69	11431.27
2005	760,885	3,840,670	4,275,728	13,373	19.81	17.80	5689.71
2006	1,085,362	6,104,220	5,208,382	17,331	17.78	20.84	6262.55
2007	1,511,315	7,351,001	8,552,818	19,534	20.56	17.67	7736.84

Source: Based on the records of the Department of Finance and the Costs and Quality Control Department.

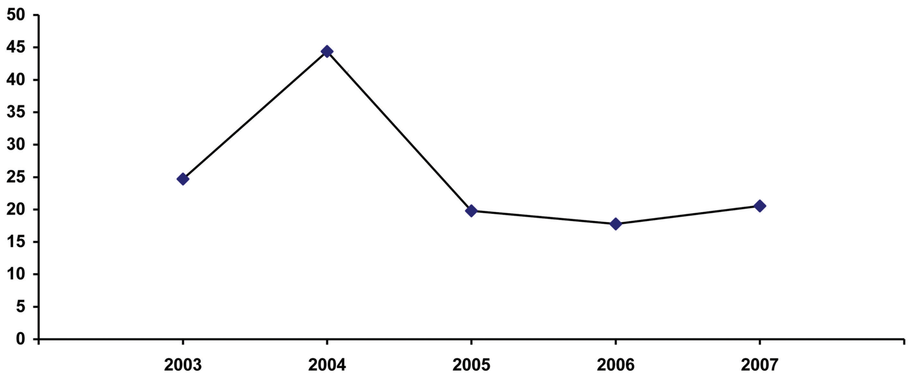

Figure 6. The cost of quality index (%) relative to the cost of production at factory 1, 2003–2007 (based on the data in Table 4). Cost index = (annual quality costs ÷ annual production costs) × 100/Sales index = (quality costs ÷ total annual value of sales) × 100/Production index = (annual quality cost ÷ annual actual production quantities) × 100 (Taylor III & Russell, 2000).

year in terms of cost of production, it fluctuates from 1 year to another; this is reflected in Figure 6. During 2004, 2005 and 2006, the quality index fell away from 19.81% to 17.78% and then rose relatively during 2006 to 20.5%. This is because of the high cost of production: in 2004, the cost of production was around 3,840,670 billion dinars; it went up significantly in 2006 (6,104,220 billion dinars) and then reached its maximum in 2007 (7,351,001 billion dinars). Quality costs rose only gradually over those 3 years. Quality index relative to value of sales ranged from 17.67% (2006) to 36.69% (2004). The reasons for an increase in this cost include poor quality, the inability to classify costs correctly and an overlap with other production costs. This reflects on the value of sales, affecting prices, profits and the organisation's ability to compete in the marketplace.

4.5 *Quality costs in factory 1 (2003–2007): Results and analysis*

As Table 4 shows, the cost of quality was in a state of change and instability, with a large rise between 2003 and 2004, a significant decline in 2005 and then an increase again in

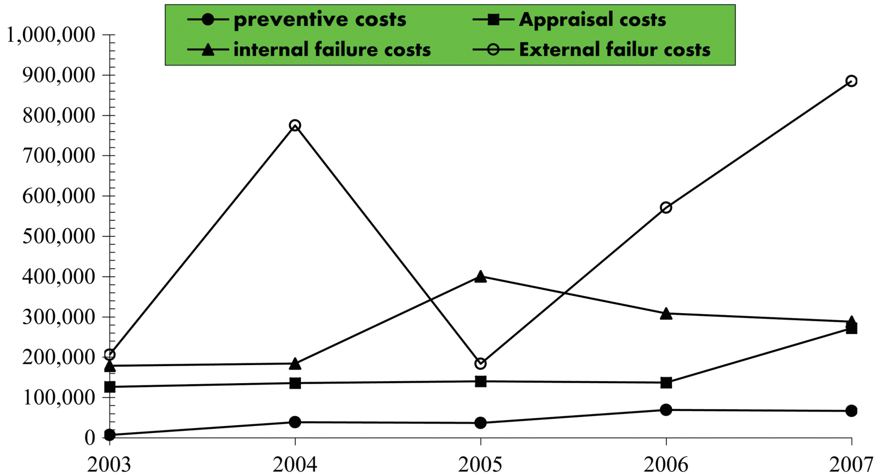

Figure 7. A model of quality costs in factory 1, 2003–2007 (based on Table 4).

2006. The majority of quality costs were concentrated in the areas of external and internal failures. The minimum level of EFCs was 24% (in 2005) and the maximum 69% (in 2004). IFCs accounted for between 16% (2004) and 53% (2005) of the total. ACs, meanwhile, ranged between 12% (minimum, 2004) and 24% (maximum, 2003). This underlines the importance of PCs, which represented a small proportion of total quality expenditure: between 1% (minimum, 2003) and 6% (maximum, 2006), as indicated in Figure 7.

Figures 8–17 explain the relationships and ratios between various types of quality costs via scatter diagrams. The general trends were as follows: (1) PCs affect total quality costs (TQCs) positively. Figure 8 shows the trend between the independent variable PCs and the dependent variable TQCs. (2) ACs affect TQCs positively.

Figure 9 shows the trend between the independent variable ACs and the dependent variable TQCs. (3) IFCs affect TQCs positively. Figure 10 shows the trend between the independent variable IFCs and the dependent variable TQCs. (4) EFCs affect TQCs positively. Figure 11 shows the trend between the independent variable EFCs and the dependent variable TQCs. (5) A change in PCs led to a similar change in ACs. There

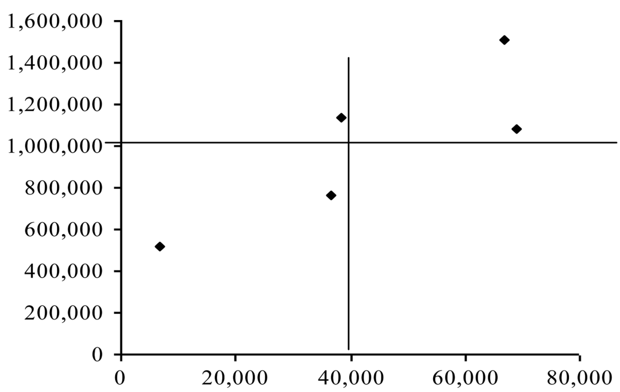

Figure 8. The relationship between PCs and TQCs in factory 1.

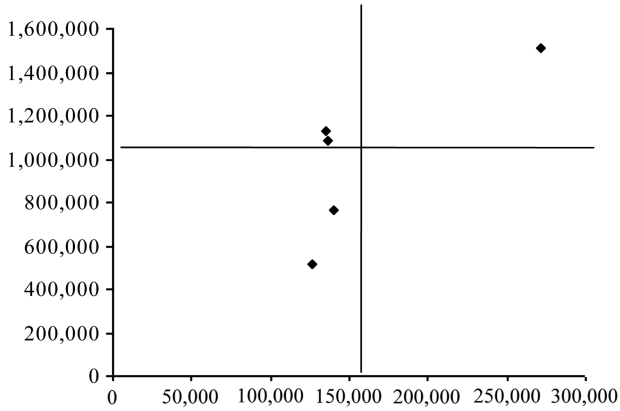

Figure 9. The relationship between ACs and costs and TQCs in factory 1.

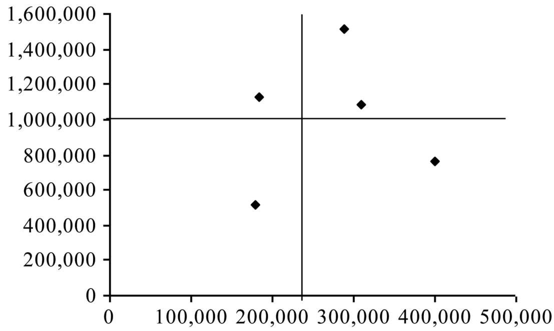

Figure 10. The relationship between IFCs and TQCs in factory 1.

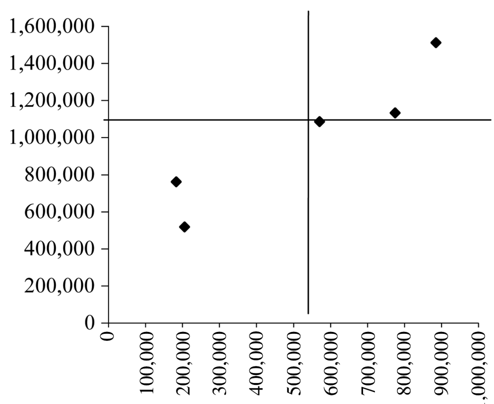

Figure 11. The relationship between EFCs and TQCs in factory 1.

was a positive relationship between the two variables, as Figure 12 shows. (6) A positive change in PCs led to a similarly positive change in IFCs, as Figure 13 shows. (7) ACs affect IFCs positively, as Figure 14 shows. (8) ACs affect EFCs positively, as Figure 15 shows. (9) IFCs influence EFCs positively, as Figure 16 shows.

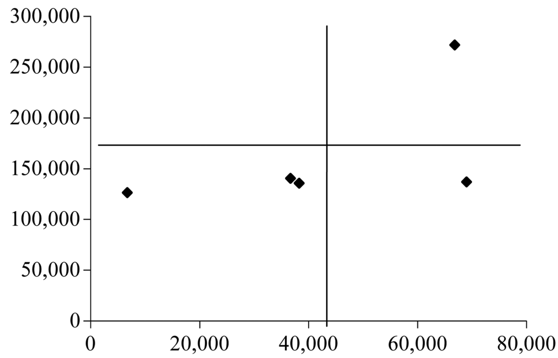

Figure 12. The relationship between PCs and ACs in factory 1.

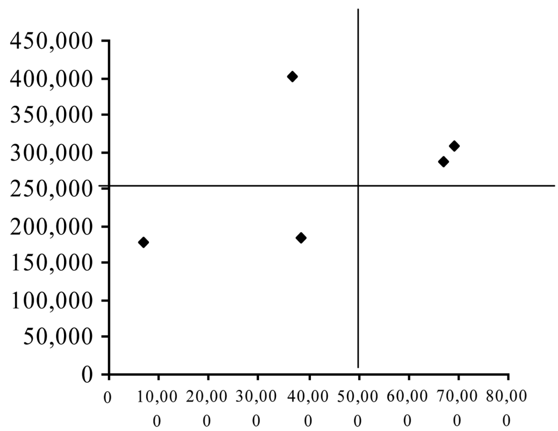

Figure 13. The relationship between PCs and failure costs in factory 1.

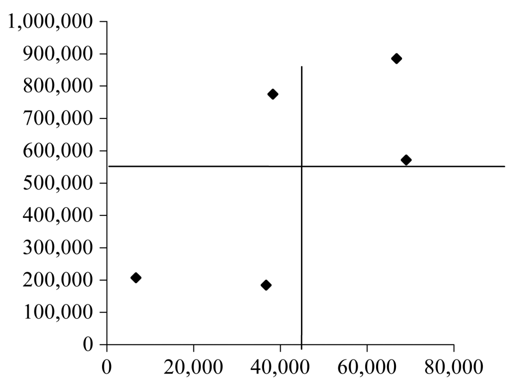

Figure 14. The relationship between PCs and costs and EFCs in factory 1.

4.6 *Measuring the relationship between TQCs and the study variables*

This section focuses on the determination of the types of relationship (correlation) and its strength between TQCs and the independent study variables (X_i), defined as follows: A: TQCs (Y); B: PCs (X_1);C: ACs (X_2); D: IFCs (X_3); E: EFCs (X_4). Table 5 details the results.

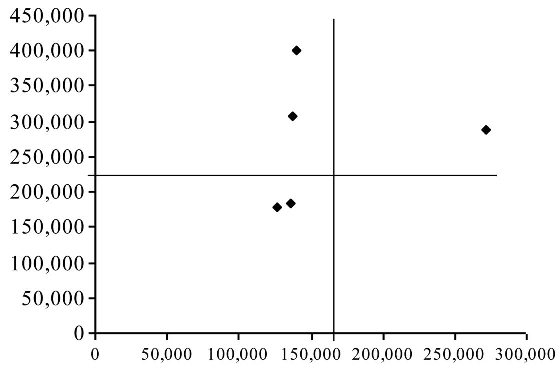

Figure 15. The relationship between ACs IFCs in factory 1.

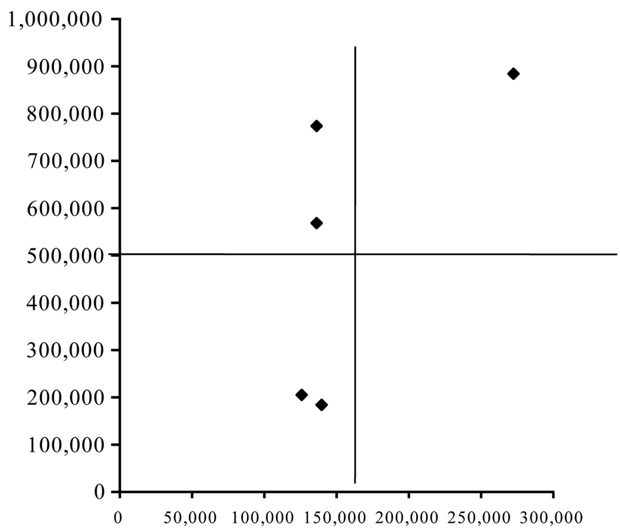

Figure 16. The relationship between ACs and EFCs in factory 1.

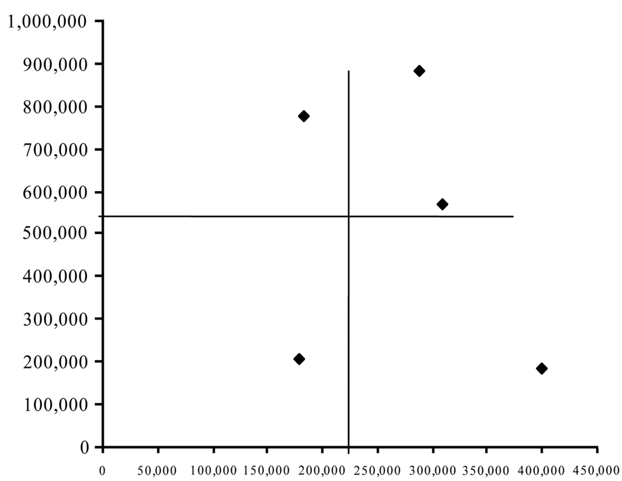

Figure 17. The relationship between IFCs and EFCs in factory 1.

Table 5. Simple correlation coefficients (*rxy*) between TQCs (*Y*) and the variables of the study (X_i).

Independent variables (X_i)	Dependent variable (*Y*)/TQCs
PCs (X_1)	0.84
ACs (X_2)	0.78
IFCs (X_3)	0.10
EFCs (X_4)	0.94*

Note: The data in Table 2 have been used to measure the correlation between independent and dependent variables.
*The simple correlation coefficient is moral with level (0.05).

4.7 *Analysis*

The computerised statistical analysis of the simple correlation coefficient (*rxy*), TQCs (*Y*) and the factors influencing it (the independent variables, X_i) generated the following conclusions: (1) The simple correlation coefficient (*rxy*) between *Y* and the cost of external failures (X_4) (0.94) means that there is a very strong and direct correlation between *Y* and X_4. This means that any increase in X_4 will lead to a significant increase in *Y*, and vice versa. (2) On the other hand, it is observed that the simple correlation coefficient ($rxy = 0.94$) is at the moral level statistically (0.05). (3) The simple correlation coefficients between *Y* and PCs (X_1) and ACs (X_2) (0.84 and 0.78, respectively) indicate a direct and strong correlation between these variables. (4) Therefore, an increase in any of the above variables (or a combination of them) will lead to an increase in *Y*, and vice versa. However, the coefficients are moral with level (0.05, 0.01). (5) The simple correlation coefficient between *Y* and IFCs (X_3) (0.10) indicates that the relationship (direct correlation) was very poor between these variables. (6) Therefore, any increase in X_3 will lead to a slight increase in *Y*, and vice versa. Also, the coefficients are moral with level (0.05, 0.01). Table 6 shows the final results for the estimation of the relationship between *Y* and X_i in accordance with the four multiple regression models.

In comparison, the values of the statistical variables and the standards to estimated models for *Y* in Table 6 indicate the chosen optimal model. Where the Logarithmic model exceeds each of the statistical tests and the entire standard, the final format of the model is:

$$\text{Log } \hat{Y} = 4.44 + 0.43 \text{ Log } X_1 + 0.44 \text{ Log } X_2 + 0.5 \text{ Log } X_4,$$
$$t = (16.24)(25.37)(16.15)(21.12),$$
$$R_y = 0.99, \quad R^2 = 99\% \quad R^{-2} = 98\%,$$
$$F = 429.22, *, \text{sE}\hat{Y} = 0.01, \text{DW} = 2.31.$$

4.8 Assessment of the relationship between TQCs and the study variables

4.8.1 *Data classification*

Table 7 below explains the data classification to make a start in the analysis.

The annual production referred to in Table 8 comprises silk fabrics and synthetic fibres (viscose fibres) as well as blended fabrics (80%) and cotton (20%). Viscose comprises 50% and the fabrics used in the production of cotton comprise 50%. Viscose is produced and processed using the same production lines. On the arrival of the product at the final stage, it would go into one of the following three categories: (1) a high-quality product

Table 6. Result of the estimated regression model (Log) of total quality cost (Y).

Type of model	Multiple regression model estimated	$sE_{\hat{Y}}$	R_y	R^2	R^{-2}	F_{cal}	DW	Decision
Logarithmic	$\text{Log } \hat{Y} = 4.44 + 0.43 \text{ Log } X_1 + 0.44 \text{ Log } X_2 + 0.5 \text{ Log } X_4$, t:(16.29)(25.37)(16.15)(21.12)	0.01	0.?99	0.99	0.?98	429.22	2.31	The optimal model

Source: SPSS Software.

t-

Table 7. Categorisation of annual production data.

Year	Production		High quality, first time		Re-work		Scrap	
	Quantity (metres)	Cost (dinars)	Quantity (metres)	Cost (dinars)	Quantity (metres)	Cost (dinars)	Quantity (metres)	Cost (dinars)
2004	9,907,271	2,552,691,609	9,529,627	2,454,064,240	231,900	60,437,974	145,744	38,189,395
2005	13,373,221	3,840,669,213	12,667,806	3,639,561,963	336,650	94,079,324	368,765	107,027,626
2006	17,330,598	6,104,219,554	16,391,661	5,779,711,766	379,134	129,899,155	559,803	194,608,633
2007	19,534,147	7,351,000,099	18,621,145	7,008,814,254	350,792	128,573,254	562,237	213,612,591

Source: Based on the records of the Department of Finance and the costs and Quality Control department.

Table 8. The total costs of re-worked products in factory 1 (2004–2007).

Year	Basic manufacturing costs (dinars)	Additional manufacturing costs (dinars)	Total costs (dinars)
2004	60,437,974	3,061,080	63,499,054
2005	94,079,624	4,443,780	98,523,404
2006	129,899,155	5,004,569	134,903,724
2007	128,573,254	4,630,454	133,203,708

Source: The records of the factory.

Table 9. Actual annual production costs in factory 1 (2004–2007).

		Annual production costs (dinars)		
Year	Actual amount of production (metres)	Basic cost of production	Re-working costs	Total cost
2004	9,761,527	2,552,691,609	3,061,080	2,555,752,689
2005	13,004,456	3,840,669,213	4,443,780	3,845,112,993
2006	16,770,795	6,104,219,554	5,004,569	6,109,224,123
2007	18,971,937	7,351,000,099	4,630,454	7,355,630,553

Source: Records of Production and Quality Control Department.

hat goes through the examination process first time; (2) a product with flaws that can be addressed, and after these additional processes the product will be ready; and (3) a damaged product that cannot be processed and will be sold in the form of clippings (scrap). The total production costs in Table 8 were calculated on the basis of direct manufacturing, but additional production costs were added to the re-worked product in order to make it free of defects, as shown in Table 8 (basic costs, additional costs and total costs).

Defective units can result in the product returning to previous stages of production, as required, leading to additional manufacturing costs. Therefore, the total cost of the re-worked products will be more than the cost of basic production because of the additional costs incurred by the repetition of processes or the addition of extra processes. Table 9 outlines the costs of the actual annual production in the factory.

From Table 9, it is possible to explain the following matters; Basic costs: annual expenditure on the product for the purpose of achieving actual production, including production costs for scrap and defective products. Total annual production: total annual expenditure on 'first-time' products, scrap and defective products. The total annual cost of production includes both basic costs and additional costs for returned and re-worked products where the manufacturing costs include direct and indirect work costs. Therefore, the data presented in Tables 8 and 9 can be used to illustrate the composition of relationships and ratios for the purpose of testing the correlation between means of improving quality, all forms of productivity and costs. Quality costs (main costs and sub-costs) are the basic element for the purpose of analysing these relationships. The results are classified by quality costs in Tables 10 and 11.

Tables 10 and 11 showed that the costs of quality assurance for 2004–2007 were 173,759,413; 176,925,113; 205,909,763; and 338,543,313 dinars, respectively, compared with the costs of internal failure, which were 225,483,949; 512,015,260; 508,121,314; and 505,959,299 dinars, respectively. That means, there was an increase in the cost of

Table 10. Quality assurance cost categories in factory 1 (2004–2007).

Costs (dinars)	2004	2005	2006	2007
	PCs			
Quality planning costs	95,400	106,000	165,150	217,475
Product design costs	38,211,075	36,572,875	59,788,250	53,143,675
Training costs	15,600	45,100	73,600	107,100
Process costs	–	–	9,000,000	13,350,000
Total PCs	38,322,075	36,723,975	69,027,000	66,818,250
ACs				
Quality testing and selection costs	141,038	141,038	8,406,038	8,406,038
Quality equipment maintenance costs	80,000	120,000	200,000	200,000
Audit quality costs	216,300	326,700	744,025	937,325
Cost of materials used in testing	135,000,000	139,613,400	127,532,700	262,181,700
Total ACs	135,437,338	140,201,138	136,882,763	271,725,063

Source: Records of the factory's accounts department, costs department, training department, research and development department and industrial safety department.

Table 11. Internal failure cost categories in factory 1 (2004–2007).

Costs (dinars)	2004	2005	2006	2007
IFCs				
Additional costs for re-working products	133,203,708	134,903,724	98,523,404	63,499,054
Scrap costs	213,612,591	194,608,633	107,027,626	38,189,395
Process failure costs	159,143,000	178,608,957	306,464,230	123,495,500
Total	505,959,299	508,121,314	512,015,260	225,183,949

Source: Electronic records from inventory control, division of statistics and quality control.

sub-standard products compared with the cost of quality assurance because of a poor focus on quality. There are weaknesses in the control of production processes: the quality-control staff examine only one sample during the first hour of production, leaving the rest of the work hours without examination. This examination is not repeated on some days, resulting in defects in the final product. As well as that, there is weakness in the application of control using quality tools. Histograms are not used because of lack of knowledge and lack of information about previous operations.

Moreover, the factory completely ignores the additional costs borne by the affected product for the purpose of re-working; the company did not measure such costs in some factories. Moreover, production quantities and additional costs bounced. These have been linked with an incentives system for the purpose of reducing additional costs following the efforts of the researcher, the director of QC and a representative from the accounts department. Table 12 shows that the change in quality assurance costs was small compared with the costs of internal failure.

4.8.2 *The relationship between improving quality, productivity and costs in factory data*

This section explains the relationship between the use of methods to improve quality, productivity and costs using the factory data mentioned in the literature review, Equation (1) in Table 13.

Table 12. Classification of TQCs in factory 1 (2004–2007).

	Quality costs (quality assurance)			IFCs				
Year	PCs	ACs	Total	Product re-work costs (basic costs + additional costs)	IFCs	Waste costs	TQCs	Total costs of poor quality
2004	38,322,075	135,437,338	173,759,413	63,499,054	38,189,395	123,495,500	225,483,949	399,243,362
2005	36,723,975	140,201,138	176,925,113	98,523,404	107,027,626	306,464,230	512,015,260	688,940,373
2006	96,027,000	136,882,763	205,909,763	134,903,724	194,608,633	178,608,957	508,121,314	714,031,077
2007	66,818,250	271,725,063	338,543,313	133,203,708	213,612,591	159,143,000	505,959,299	844,502,612

Source: Table 2.

Table 13. Ratios and relationship summaries (2004–2007).

Year	Ratio of good quality to quantity (%)	Ratio of good quality costs (%)	Ratio of PCs (%)	Ratio of quality to costs (%)	Ratio of poor quality (%)	Amount of poor quality for defective production and re-work	Ratio of poor quality costs (%)
2004	98	43.6	9.6	17	3.87	377.644	56.4
2005	97	25.7	5.3	17	5.42	705.415	74.3
2006	98	28.8	9.6	12	5.60	938.937	71.2
2007	98	40.1	7.9	11	4.81	913.029	69.9

Source: Results of Equation (1).

Table 13 highlights the level of 'first-time' good quality products (98%, 97%, 98% and 98%) for 2004–2007. This is lower than the acceptable level of quality which is 99.6%. The ratio fluctuates, which is an indication of a lack of focus and attention to quality which is a vital element in competitive advantage. Therefore, the ratio of good quality costs increased compared with other costs, denoting a lack of attention and focus on quality (43.6%, 25.7%, 28.8% and 40.1%) respectively. Also, the ratios of poor quality were correspondingly 38.7%, 54.2%, 56.0% and 48.1%; these were below the required level, except in 2004 and 2007. This indicates the low efficiency of the methods used, which have allowed the passage of a large proportion of poor-quality goods.

On the whole, the percentages varied from year to year and were below the required 50%. Logothits (1997) stated that 50% is the ratio that would balance good quality costs with poor quality costs. These were grouped as follows: (1) PCs are 10% of the TQC. (2) ACs constitute 40% of the TQCs. (3) IFCs and EFCs constitute 50% of the TQCs. The preventive ratios should be of interest to the factory. Quality procedures will enable it to achieve the required quality; it is assumed that a ratio of products that are acceptable the first time should not be less than 50%. The factory's ratios have been very low, 9.6%, 5.3%, 9.6% and 7.9%. These ratios confirmed the lack of focus on avoiding errors and defects in the course of production processes. Moreover, the ratios have fluctuated from year to year, with another sign of a lack of accurate planning. The ratios suggest that QC processes are unclear in the factory.

However, for the purpose of understanding these ratios effectively, they must be analysed alongside the preventive ratios, which are good indicators of the extent of attention to quality. When these percentages decrease compared to a rise in PCs, this is a good reflection of the impact of preventive measures on TQCs. The quality ratios to costs were 17%, 17%, 12% and 11%, respectively. These percentages are low compared with the preventive ratios; this demonstrates the weakness of the monitoring system in achieving the required level of quality. Generally, the results of the ratios analysis are consistent with the traditional approach to quality, which has been mentioned in the theoretical section of this study.

Additionally, Table 13 shows fluctuation in these rates and instability during the years of this investigation, as well as a decline relative to the acceptable ratios of an effective quality system. This means the factory suffers from technological obsolescence. Also, there are weaknesses in the control on the manufacturing processes, in particular, the appropriate storage of raw materials. This is because management did not develop an efficient air-conditioning system or technological adaptation for the factory machinery that could convert the fabrics to cotton products or mixed products (cotton and fabrics). The remainder of the ratios are presented in Equations (2) and (3). Table 14 explains

Table 14. Summary of production quantities, yield and QPR.

Year	Yield amount	Yield cost	QPR (%)
2004	9,761,527	261.818	4
2005	13,004,456	295.676	3
2006	16,770,795	364.277	2
2007	18,971,937	387.711	2

Source: Count of the equations for the yield costs and QPR.

Table 15. The ratios and relationships between quality, productivity and costs for 2004 in factory 1.

Year	High-quality ratio	Costs ratio of good quality	Preventive ratio	Quality ratio	Poor quality ratio	Costs ratio of poor quality	Amount of poor quality (metres)	Yield	Cost of yield	Ratio of quality to productivity
2004	98%	43.6%	9.6%	17%	38.7%	56.4%	377,644	9,761,527	261,819	4%

Source: The results to the previous analysis.

the relationship among the ratios to yield costs and QPR according to Equations (2) and (3), and as follows.

Table 14 highlights to us that the ratios of quality to productivity during 2004, 2005, 2006 and 2007, were 4%, 3%, 2% and 2%, respectively. The ratios were lower in 2005, 2006 and 2007 compared with 2004, and there was a further decline in 2006 and 2007 compared with 2005. This indicates a negative relationship between the improvement of quality, productivity and costs. This also confirms the previous results of the analysis, which indicated that the ratios and relationships in 2004 differ somewhat from those of 2005, 2006 and 2007. The high rates of the cost of good quality, prevention and quality and the lower poor quality costs relative to the cost of the yield (Y), as well as the low amount of poor quality and a high ratio of quality to productivity, shows a somewhat positive relationship between quality, productivity and costs. The researcher believes that the reason behind this is a lack of production in 2004 compared with the other years. This is also because of the application of a new incentives system in the company, which has created a wider range of quality procedures. Accordingly, Table 15 summarises the ratios and relationships among quality, productivity and quality costs for the year 2004, as follows:

Analysis of the relationship between methods of quality improvement, productivity and costs highlights the credibility of the following question: ‘Is there any statistically significant relationship between methods of improving quality, productivity and costs in factory 1?’ This was done in accordance with Adam and Hershauer, and these results showed the relationship between quality, productivity and costs: the improvement in quality resulted in increased bad production and an increase in the amount of re-work, thus, leading to increased costs and lower productivity. This is because of the control system applied in factory 1 and the lower PCs compared with other quality costs.

5. Conclusion

The investigation evaluates the relationship among types of quality costs, its impact on productivity and costs in the textile industry. In this study, the achievable outcomes portray differences in each case due to the nature of various scenarios. In addition, the research presents and discusses the aim of study, literature review and the results. Consequently, from thorough interviews and data collection obtained within this organisation, three fundamental factors were identified and subsequently addressed. The result analysis shows that improving quality plays a fundamental role in increasing operations productivity in any organisation. On this premise (Deming, 1986) 14 points relate improved quality to productivity. Juran's trilogy (1974) states that an approach to cross-functional management is composed of three managerial processes: quality planning, QC and quality improvement. In addition, human aspects (senior management and employees), are significant for the construction of the relationship among quality, productivity and costs. Additionally, based on the results of our study, it may be inferred that TQM has a positive effect on TQCs and productivity. This is evident in the operational and business performances, employee relationship and customer satisfaction. These results are consistent with the QM literature.

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References

Acharya, U.H., & Ray, S. (2000). ISO 9000 certification in Indian industries: A survey. *Journal of Total Quality Management*, *11*(3), 261–266.

Adam, J.R., Everett, E., & Ebert, R. (1986). *Production and operations management: Concept, models and behaviors* (pp. 1–146). New Delhi: Prentice Hall.

Al-Dujaili, M. (2002). An impact of quality improvement on the productivity (MSc Thesis, The University of Baghdad, pp. 1–220).

Ali, K.A., & Zakria Abas, R.Y. (2001). The relationship between quality management practices and productivity in revenue and cost management: A study of local authorities in Peninsular Malaysia. *Malaysian Management Journal*, *5*(1&2), 35–46.

Arauz, R., & Suzuki, H. (2004). ISO 9000 performance in Japanese industries. *Journal of Total Quality Management and Business Excellence*, *15*(1), 3–33.

Belcher, J.G., Jr. (1987). *Productivity plus +: How today's best run companies are gaining the competitive edge*. Houston, TX: Gulf Publishing Co.

Bergman, B., & Klefsjo, B. (1994). *Quality from customer needs to customer satisfaction* (p. 43). London: McGraw-Hill.

Borton, G. (2004). Managing the Productivity and Costs of the Employee Job Life Cycle. *Primary Matters*, *902*(794–7095), 1–12.

Card, D.N. (2006). The challenge of productivity measurement. Proceedings: Pacific Northwest software quality conference, Portland, OR (pp. 1–10).

Chase, R.B., Nicholas, J.A., & Mark, M.D. (1995). *Fundamentals of operation management (2nd ed.)* (p. 123). Chicago, IL: Irwin Publishing.

Choo, A., Linderman, K., & Schroeder, R. (2004). Social and method effects on learning behaviours and knowledge creation in six sigma projects. *Academy of Management Proceedings* (pp. C1–C6).

Dahlgaard, J.J., Kristensen, K., & Kanji, G. (1992). Quality costs and total quality management. *Journal of Total Quality Management*, *3*(3), 211–221.

Dale, B.G., Y-Wu, P., Zairi, M., Williams, A.R.T., & van der Wiele, T. (2001). Total quality management and theory. *An exploratory study of contribution. Journal of Total Quality Management*, *12*(4), 439–449.

Deming, W.E. (1989). *Out of the crisis* (p. 248). Cambridge, MA: Massachusetts Institute of Technology, Center for Advanced Engineering Study.

Detoro, I.J. (1987). Strategic planning for quality at xerox. *Quality Progress, 20*(4), 16–20.

Ebrahimpour, M. (1985). An examination of quality management in Japan: Implications for management in the United States. *Journal of Operations Management*, *5*(4), 419–431.
Evans, J.R. (1997). *Production/operations management: quality performance and value* (5th ed., pp. 24–86). New York: West Publishing Company.
Heizer, J., & Render, B. (2001). *Operations management* (pp. 15–200). Upper Saddle River, NJ: Prentice Hall.
Logothetis, N. (1997). *Managing for total quality from Deming to Taguchi and SPC* (p. 207). New Delhi: Prentice Hall.
LTSN Hospitality and Leisure, Sport and Tourism (2001). *Resource guide: Employee empowerment, participation and involvement.* Learning and Teaching Support Network (pp. 1–10), available at: http://www.heacademy.ac.uk/assets/hlst/documents/resource_guides/employee_empowerment_perception_and_involvement.pdf.
Parker, C. (2000). Performance measurement. *Work Study*, *49*(2), 63–66.
Reed, R., Lemak, D.J., & Mero, N.P. (2000). Total quality management and sustainable competitive advantage. *Journal of Total Quality Management*, *5*(1), 5–26.
Rodchua, S. (2006). Factors, measures, and problems of quality costs program implementation in the manufacturing environment. *Journal of Industrial Technology*, *22*(4), 2–6.
Ross, J.E. (1995). *Total quality management, text cases and reading* (pp. 6–348). Delray Beach, FL: St. Lucie Press.
Schroeder, R.G. (1989). *Operations management* (pp. 515–581). London: McGraw-Hill.
Taylor, B.W., III, & Russell, R.S. (1995). *Production and operations management* (p. 89). Upper Saddle River, NJ: Prentice-Hall.
Taylor, B.W., III, & Russell, R.S. (2000). *Operations management multimedia version* (pp. 102–140). Upper Saddle River, NJ: Prentice Hall.
Tolentino, A.L. (2004, 13–14 May). *New concepts of productivity and its improvement* (pp. 1–7). Presented at the European Productivity Network Seminar, Budapest.
Van der Wiele, A., Willimas, A.R.T., & Dale, B.G. (2000). Total quality management. Is it a fad, fashion or fit? *Journal of Quality Management*, *7*(2), 65–79.
Wilkinson, A.D., & Cooper, C. (1997). *Managing quality and human resources. A guide to continuous improvement* (p. 2). London: Blackwell.